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Color Test Chart for Facsimile

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NCS TIB 91-16

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The purpose of this project was to generate a new set of test charts and standard images that can be used by experimenters working in the field of color facsimile. The NCS has been a leader in the development and promulgation of standardized imagery for facsimile. The NCS sponsored the scanning of documents used by the International Telegraph and Telephone Consultative Committee (CCITT) at resolutions of 200, 240, 300, 400 and 480 lines per inch and stored the resultant data on tape. This data has been used by many experimenters in the development of standard compression algorithms for digital facsimile. This work contributed significantly to the development of high resolution facsimile standards which will be of considerable value to the U.S. Government. In addition, the NCS sponsored the preparation of standard gray scale images, representative of continuous tone pictures to be transmitted through Group 4 facsimile systems. All of this past work has been directly solely at black-white imagery. This report is comprised of five sections. Section 1 provides a brief description of the objectives of the study and an outline of the contents of this report. Section 2 discusses test chart and test image requirements and describes the general set of features that satisfy the requirements. Section 3 contains (Cont'd)

Facsimile
Images
Color Test Charts

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Unclassified Unclassified Unclassified Unlimited

Item #13 (Abstract) Cont'd:

descriptions of the charts currently under development. Section 4 describes the scanned images, and Section 5 is a summary of the work performed and recommendations for further work.

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NATIONAL COMMUNICATIONS SYSTEM

TECHNICAL INFORMATION BULLETIN 91-16

COLOR TEST CHART FOR FACSIMILE

DECEMBER 1991

OFFICE OF THE MANAGER
NATIONAL COMMUNICATIONS SYSTEM
ARLINGTON, VA 22204-2199

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COLOR TEST CHART FOR FACSIMILE

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FOREWORD

Among the responsibilities assigned to the Office of the Manager, National Communications System, is the management of the Federal Telecommunication Standards Program. Under this program, the NCS, with the assistance of the Federal Telecommunication Standards Committee identifies, develops, and coordinates proposed Federal Standards which either contribute to the interoperability of functionally similar Federal telecommunication systems or to the achievement of a compatible and efficient interface between computer and telecommunication systems. In developing and coordinating these standards, a considerable amount of effort is expended in initiating and pursuing joint standards development efforts with appropriate technical committees of the International Organization for Standardization, and the International Telegraph and Telephone Consultative Committee of the International Telecommunication Union. This Technical Information Bulletin presents an overview of an effort which is contributing to the development of compatible Federal, national, and international standards in the area of facsimile. It has been prepared to inform interested Federal activities of the progress of these efforts. Any comments, inputs or statements of requirements which could assist in the advancement of this work are welcome and should be addressed to:

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COLOR TEST CHART
FOR
FACSIMILE

December, 1991

DCA100-83-C-0047

Submitted to:
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CODE NT
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1. INTRODUCTION

This document summarizes work performed by Delta Information Systems, Inc. (DIS) for the National Communications System (NCS), Office of Technology and Standards. This office is responsible for the management of the Federal Telecommunications Standards Program, which develops telecommunications standards, whose use is mandatory for all Federal departments and agencies. The purpose of this project, performed under contract number DCA100-83-C-0047, was to generate a new set of test charts and standard images that can be used by experimenters working in the field of color facsimile.

The NCS has been a leader in the development and promulgation of standardized imagery for facsimile. The NCS sponsored the scanning of documents used by the International Telegraph and Telephone Consultative Committee (CCITT) at resolutions of 200, 240, 300, 400 and 480 lines per inch and stored the resultant data on tape. This data has been used by many experimenters in the development of standard compression algorithms for digital facsimile. This work contributed significantly to the development of high resolution facsimile standards which will be of considerable value to the U. S. Government. In addition, the NCS sponsored the preparation of standard gray scale images, representative of continuous tone pictures to be transmitted through Group 4 facsimile systems. All of this past work has been directly solely at black-white imagery.

The CCITT is now in the process of developing a standard for the transmission of color imagery as part of the facsimile recommendations. The digital transmission of color imagery is of particular importance to the Government for transmission of photographs, half tones, maps etc. Unfortunately, there exists no set of standard color test charts which can be used by all experimenters in the facsimile field. The purpose of this project is to develop such a set of standard test charts and associated digital images for color facsimile applications.

The purpose of compiling a standard set of images is to make the results presented by various experimenters in the field directly comparable, without regard to differences in image content. As a result of this project, all experimenters

engaged in performing studies for the CCITT will have access to magnetic tapes or DOS diskettes containing digitized versions of the standard images. In addition, the images will be useful in evaluating graphic printer quality and capability.

This report is comprised of five sections. Section 1 provides a brief description of the objectives of the study and an outline of the contents of this report. Section 2 discusses test chart and test image requirements and describes the a general set of features that satisfy the requirements. Section 3 contains descriptions of the charts currently under development. Section 4 describes the scanned images, and Section 5 is a summary of the work performed and recommendations for further work.

2. TECHNICAL DISCUSSION

2.1 Test Chart Requirements

The CCITT is now in the process of developing recommendations that will accommodate the transmission of color imagery by means of facsimile. In order to measure and verify the quality of the facsimile apparatus, it is necessary to have a standard color test chart.

Much effort has gone into the generation of gray scale facsimile test material resulting in very useful documents. Although these documents are also applicable to color facsimile systems, the color test chart expands the transfer characteristics tested to include chromaticity, and to provide more stringent gray scale requirements.

The purpose of this section is to present some of the major issues involved in developing a standard color test chart, and to list some features that might be included in such a chart.

2.1.1 Test chart design

The following are among the factors that influence the design of a color test chart:

the intended purpose of the test chart;

the range of parameters to be tested;

the features to be included in the test chart; and

the feasibility (cost) of producing the test chart.

2.1.1.1 Purpose of the Test Chart

A test chart may be used in many ways. The following are among the more important:

a) It may be used to determine the range of capabilities of a given device on an absolute basis such as during design or in comparing the capabilities of one device with another.

b) It may be used to determine how well a device is operating within a given set of specifications (for example, for acceptance or for operational status verification).

c) It may be used to assist maintenance personnel to locate and correct faults.

A test chart is used to measure the transfer characteristics of a device or a system. The test chart provides a precisely defined input to the facsimile device. The hard copy output of the system is compared to the input (test chart) to determine the effect that transmission through the system has had on the various contents of the test chart. The characteristics of these contents are very carefully designed and produced so that they specifically test the transfer characteristics of major system parameters which control specific aspects of the output quality.

2.1.1.2 The Range of Parameters to be Tested

As stated above, the use of a color test chart is a method of comparing the color output document of a facsimile system with a standard color input document, providing a means of analyzing the transfer characteristics of the system. In order to evaluate the performance of the system, including all of its components, the features of the test chart must contain material which will demonstrate the function and capability of each component. The following tabulation includes some of these functions and capabilities:

Sensor pick-up characteristics

- Primaries
- Sensitivity
- Dynamic range
- Linearity
- Resolution
- Spectral characteristics of illumination

Signal processing characteristics

- Sampling density
- Digitizing precision (quantization)
- Digitizing linearity
- Coding quantizing precision
- Coding sampling density
- Coding color sampling precision

Color printing characteristics

- Primaries
- Use of black
- Additive or subtractive
- Linearity
- Dynamic range
- Output media characteristics
- Viewing conditions
- Printing density

In addition, the range of characteristics of normal input material should be considered since it forms the boundary of parameters for which the facsimile system was designed.

Color facsimile systems can be categorized as continuous color or discrete color systems. Continuous color implies that the output rendition shows no

contours in color. Continuous tone could be produced by an analog system or a digital system with an extremely high number of quantizing steps in both luminance and chromaticity characteristics. Discrete systems have specific levels of quantization which will produce only specific numbers of colors in the output document by design. For example, eight-level quantization in each primary can produce 256 x 256 x 256 or 16,777,216 color combinations of luminance, hue, and saturation. The test chart must accommodate the needs of both analog and digital systems.

This tabulation of function and capability characteristics must be analyzed and a set of technical parameters developed which will stress these characteristics to permit their evaluation.

2.1.1.3 The Features to be included in the Test Chart

The range of features and technical parameters generated from the requirements of the previous section which can be used to specify a test chart include the following:

- Reflectivity of the test chart stock
- Chromaticity of the test chart stock (hue and saturation)
- Form of the test patterns, blocks, etc.
- Reflectivity, hue, and saturation or range of reflectivity, hue, and saturation of each pattern
- Number and size of the increments of the reflectivity, hue, and saturation in the patterns
- Reflectivity characteristic (degree of specularity or diffusion)
- Line widths, spacing, and density for resolution test.
- Density and density variation for gray scale test.

The selection of the specific patterns and the specific values of the tabulated parameters to be incorporated into the test chart is the subject of this study. Some general suggestions are presented in Section 2.2. Some of the considerations for determining the range of these parameters are discussed below.

A precise gray scale may prove to be essential in determining the ability to reproduce colors correctly. For example, any variance in the transfer characteristics between the three spectral channels in an RGB system will produce some degree of chromaticity in the reproduction of various parts of the neutral gray scale.

There is a considerable degree of difficulty and expense in producing and, even more so, in reproducing large quantities of test charts with certain characteristics. A very wide range of color is one of these characteristics. Precise tolerance of the chromaticity is another. These are major considerations in establishing the final test chart design. Therefore, rather than specifying very wide ranges of chromaticity for inclusion into the test chart in order to be all encompassing, perhaps it would be best to first determine the following:

The range of reflectivity and chromaticity to be expected in various types of input material.

The dynamic range and the primary chromaticity points of the sensor-illumination combination of a wide range of practical facsimile systems.

The range of capabilities of the facsimile output material.

The characteristics of the signal processing part of the facsimile system.

An approach to utilizing the data thus gathered might be to plot the chromaticity thus determined on a CIE chromaticity diagram (See Figure 1). The locus of the points plotted will constitute, to a first approximation, the gamut of all the chromaticities to be considered. This should be a great aid in determining one of the major specifications for the test chart.

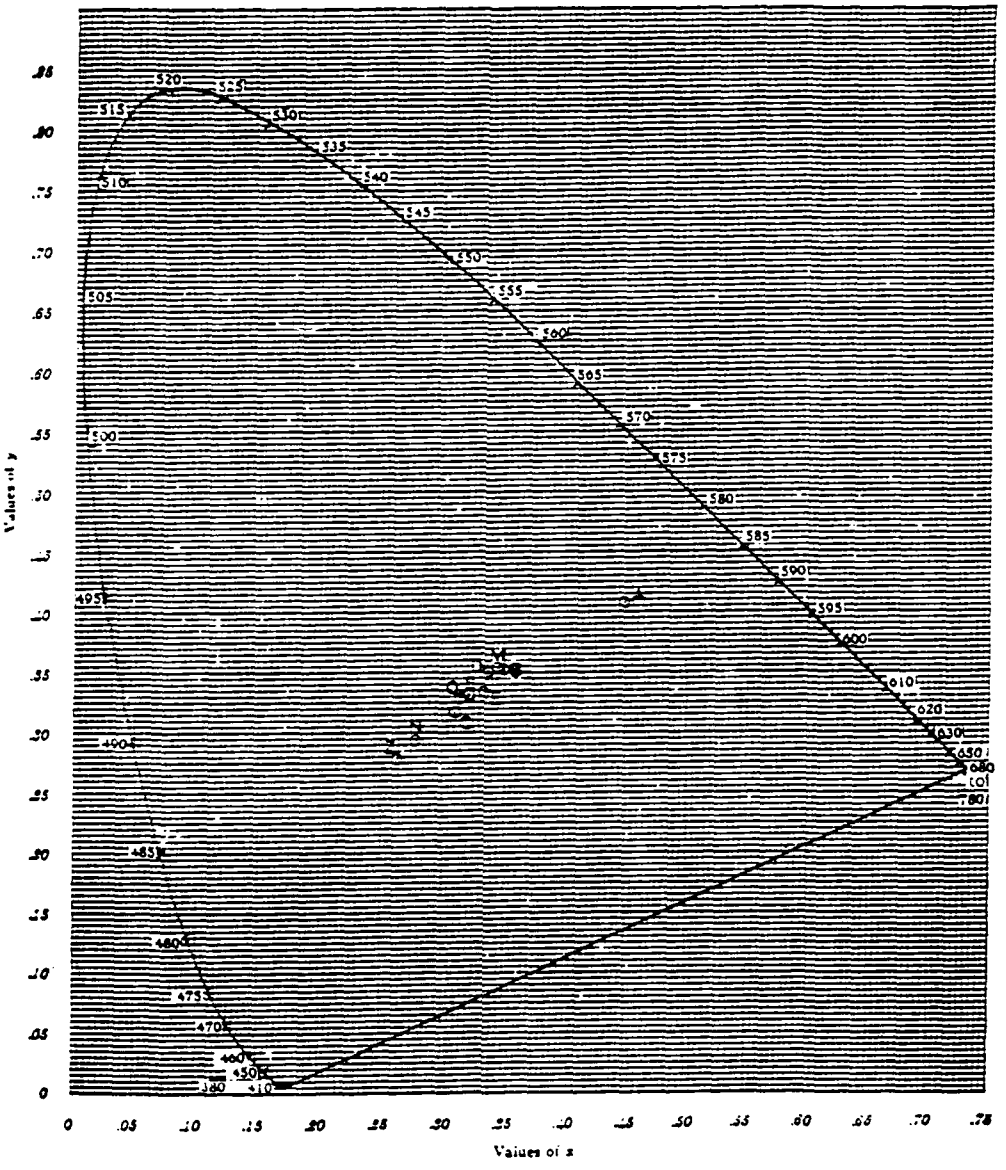


FIGURE 1 - CIE CHROMATICITY DIAGRAM

2.1.1.4 Feasibility of Producing and Reproducing the Color Test Chart

The previous section included a discussion of the selection of the material and the color characteristics to be incorporated into the test chart specification. As indicated, it is difficult to provide certain features, and impossible to provide others such as spectral colors, which might be desirable. Also, it may not be practical to include all of the required features of the test chart on a single sheet. One possible division is to place the resolution related elements on a monochrome sheet, and the color related elements on another sheet.

The production of high quality test charts is a rather restricted business area. The generation of test charts is substantially different from the generation of high quality color art work. It requires meeting detailed specifications for reflectivity and chromaticity in addition to resolution and other parameters on the "standard" gray scale charts. Therefore it is important that the concept of the test chart require only the use of realizable colors. The production of the test chart can also be greatly simplified if the colors specified are "standard colors" such as those contained in various vendor catalogs. This eliminates the need for the generation, experimentation, and documentation required to produce a new reproducible color chip.

It is not known how accurate the color rendition will be for received copy in color facsimile systems. Specifying colors accurately can be very complex. For example, the C.I.E. standards of 1931 and 1976 require five different standard illuminant sources. The associated chromaticity diagrams have x and y (or u' and v') numbers for every color. Although equipment is not widely available for working directly with this standard, some work has been done on conversions between C.I.E. numbers and the Pantone system, a commonly used personal computer program. High quality color scanners generate 256 steps (8 bits) for each primary color. Pantone has a separate number set with red, green, blue, hue, saturation, and brightness being shown on the computer screen for each of these colors. Although this program provides far more precision than needed, it is relatively easy to use and the same Pantone colors are available at color print shops. It may also be used as a convenient method of identifying the colors in a

computer digital image file. This digital image file containing the complete test chart would allow the facsimile printing portion (facsimile recorder) to be checked by itself, independent of the scanner. The facsimile scanner could be used to generate a digital computer file from the test chart for comparing the Pantone color numbers with those for the solid color patches of the test chart.

The foregoing discussion does not imply that the function and useability of the color test chart should be compromised in any way. Rather, it is assurance that the implementation and reproduction of such a chart is practical.

2.1.2. Test chart elements

Examples of the kinds of features that might be included in a standard color test chart are:

- a color photograph representing the maximum possible number of different colors,

- tone scales of primary colors (red, green, blue), each scale being represented by eight (up to sixteen) fields, each pair of adjacent fields having a constant prescribed saturation value difference,

- tone scales of the subtractive primaries or secondary colors (yellow cyan, and magenta), each scale being represented by eight (up to sixteen) fields of prescribed saturation values,

- a tone scale of gray (neutral color) with 16 fields of prescribed optical densities,

- test fields for measuring resolution and geometrical distortion as in test charts for document facsimile transmission,

- truncated fan-type multiple-line test pattern similar to IEEE Std 167A-1986,

- W. and L. E. Gurley type Pestrecov Star pattern,

- NBS type Microcopy Resolution test pattern. Numerals indicate the number of cycles or line pairs (one black plus one white line) per millimeter,

- halftone dot screens,

- character strings of various types and sizes.

2.1.3 Test images

A number of generally desirable characteristics to be incorporated into a set of standard color test images might include:

1. A gradual transition in color over a broad image area (to show possible contouring effects of certain compression algorithms);

2. A range of textures and other small, repetitive patterns;

3. Sharp vertical, horizontal, and diagonal boundary transitions between various color combinations;

4. Areas of high detail/contrast to challenge compressibility;

5. Images which display widespread variations in luminance, hue, and saturation;

6. Subject material representative of typical applications.

In performing the selection of the standard color images, it will be necessary to establish certain physical characteristics associated with the images. The image

size of the standard gray scale set, approximately four inches by five inches, seems the logical choice for the color set as well, for the same reasons; this size offered a compromise between algorithm simulation considerations and applications considerations. On one hand, a small image is easier to process, requiring less computer time and mass storage. Also, a soft copy high resolution display is typically limited to 1000 to 2000 lines resolution, while standard TV is limited to 500 to 600 lines. On the other hand, the image should be large enough to evaluate visually and should be of a size on the order of that in an actual application.

The resolutions of the color test images must be determined. At least 400 pixels per inch in both the horizontal and vertical directions should be provided. The digitization of the color images involves encoding each of the primary components of the color spectrum (i.e. red, green, and blue) typically with eight bit precision, since this is both a convenient number for most computer simulation facilities and it provides for a significant amount of color variations without requiring excessive computer storage.

The selected color test images must be scanned, digitized, and written on magnetic media at the required resolutions. Each component of each test image at each resolution should be stored. Also to be included might be soft copy "windows" of each color image, displayable on RGB compatible monitors. The purpose of the soft copy windows is to present visual representations of the digitized images and to provide smaller areas of the test images that are characteristically representative of the overall images from which they were extracted.

2.2 Proposed Implementation

The original intent of this project was to satisfy the color test chart requirements with a single chart. However it became evident that in order to provide the highest quality at the least cost, more than one chart would be required. One way to minimize reproduction costs is to partition the desired chart elements so that each set can be reproduced in the most cost effective way. For example, a set of three charts might be defined including a gray scale chart, a

printed color chart and a photographically reproduced color chart:

1. A monochrome continuous tone gray scale chart with adequate resolution for Group 4 (and the soon to be upgraded Group 3), and a wide range of tone densities. This chart could be reproduced photographically (similar to the IEEE chart).

2. A color chart of constant density, including fine lines, high resolution patterns and half-tone patterns. This chart could be printed by a four-color process.

3. A continuous tone color chart including a photograph and primary colors of varying density and saturation, with no high resolution patterns. This chart could be reproduced photographically.

A possible implementation of the gray scale chart (category 1 above) contains the elements described below:

1. Border of 4 scales similar to Rec T.21. These scales permit determination of distortion in length of horizontal and vertical lines by direct measurement with a graduated scale. Lines at the corners have been extended to the edge of the chart to check total scan width and length.

2. B/W bar patterns of 10, 50, 100, 200, and 400 LPI, for square wave testing. (For the final chart these lines will be 2.5 degrees oblique similar to Rec T.21 Chart 3, pattern 3.6.)

3. Low contrast 96 LPI bar patterns of white/light gray and black/dark gray. For testing high modulation rates near white and black. For testing modulation characteristics at edges of band in a frequency shift system.

4. A continuous (stepless) density wedge from black to white.

5. A 64 step tablet with 4 rows of 16 density steps from black to white. Steps are designed for equal perceptibility to a human observer. If a test is

required in reverse step order, the last chart may be sent upside down.

6. Gurley type Pestrecov Star pattern with circles of 50, 100, & 200 LPI.

7. Vertical truncated fan-type multiple-line pattern with low taper rate. Calibrated from 40 to 600 LPI.

8. NBS type resolution pattern calibrated in line pairs (black plus white) per millimeter.

9. Photograph of girl. The very gradual gray scale gradations make it easy to see distortion of gray scale.

10. Tapered black and white vertical lines with width calibrated in microns. For measuring single line resolution.

11. Hexagonal line patterns 2,3, & 4 are ISO characters for readability tests.

12. Horizontal truncated fan-type multiple-line pattern with low taper rate. Calibrated from 40 to 600 LPI.

13. Isolated black and white lines. For measuring single line resolution.

14. Line crossing pattern. For measuring the vertical line pitch. Number of scanning line crossings of both lines multiplied by 7.7 will equal the number of lines per inch. Multiply by 3 for the number of lines per millimeter.

15. Japanese Kanji text, 10.5 & 7.875 P.

16. English text, 12, 10, 8, 6, 4, & 2 pt.

17. Halftone dot screens of 10, 50 and 90% black. The 65 and 90 are the number of dots per inch measured at a 45 degree angle.

18. NBS type resolution pattern calibrated in line pairs (black plus white) per

millimeter. For checking corner and angle resolution.

19. Diagonal line. For checking irregularities in vertical pitch.

20. Dot triangle. The 3 dots "A" and the 3 dots "B" form 3, 4, 5 triangles (6, 8, 10 inches). For measuring skew. (This pattern could be eliminated and the diagonal of the border measured. The difference multiplied by a constant would give skew.)

Note that the current design of the test chart set provides for four separate charts. Descriptions and current status of these charts are provided in the next section.

3. TEST CHART DESCRIPTIONS

Test chart requirements our outlined in the previous section. There has been some discussion on how to partition the desired chart elements so that each set can be reproduced in the most cost effective way. The original partitioning, described in section 2.2, provided for a monochrome chart on a single sheet. The intent was to produce a chart similar to the IEEE test chart but of much higher quality to match the capabilities of current facsimile technology. After assembling the negatives to produce the monochrome chart, we found that the chart could not be printed with the desired quality due to the limitations of the printing process and printing material. Therefore it was decided to separate the chart into two parts to allow the text and line work to be printed with optimum sharpness and contrast in one part, and the continuous tone portion to be printed in a second part on lower contrast photographic material. Then the current chart partitioning is as follows:

1. A monochrome high resolution, high contrast chart with text in various type fonts and patterns for checking both single-line and multiple-line resolution performance.

2. A monochrome continuous tone gray scale chart with a "long" gray scale. Includes calibrated continuous and stepped density values and one or more photographs.

3. A color chart of constant density, including fine lines, high resolution patterns and half-tone patterns. This chart could be printed by a four color process.

4. A continuous tone color chart including a photograph and primary colors of varying density/saturation. No high resolution patterns. This chart could be reproduced photographically.

Descriptions and status of these four charts are described in the following sections.

3.1 High contrast monochrome chart

This chart has been titled "BLACK-WHITE FACSIMILE TEST CHART" (BW01), and is printed on high gamma phototypesetting paper. The fine lines on this chart are printed at full contrast, with the black line width the same as the white spaces between lines up to more than 800 black plus white lines/inch. The B/W resolution patterns were optically reduced from much larger printouts at 2540 dpi, to make them essentially stepless. The overall size of the printed chart is 8 3/4 x 11 3/4 inches to allow for maximum paper size tolerances. The patterns that make up the chart are defined below. Refer to the corresponding encircled numbers in Figure 2. This chart is being progressed in Study Group VIII as a draft recommendation (T.xx); refer to Appendix A for the text of this draft recommendation. Test prints of this chart are available for review.

1. CCITT border of 4 scales with millimeter markings. The 5 and 10 mm lines are extended. The arrows near the ends are 8 1/2 inches apart and centered on the page.

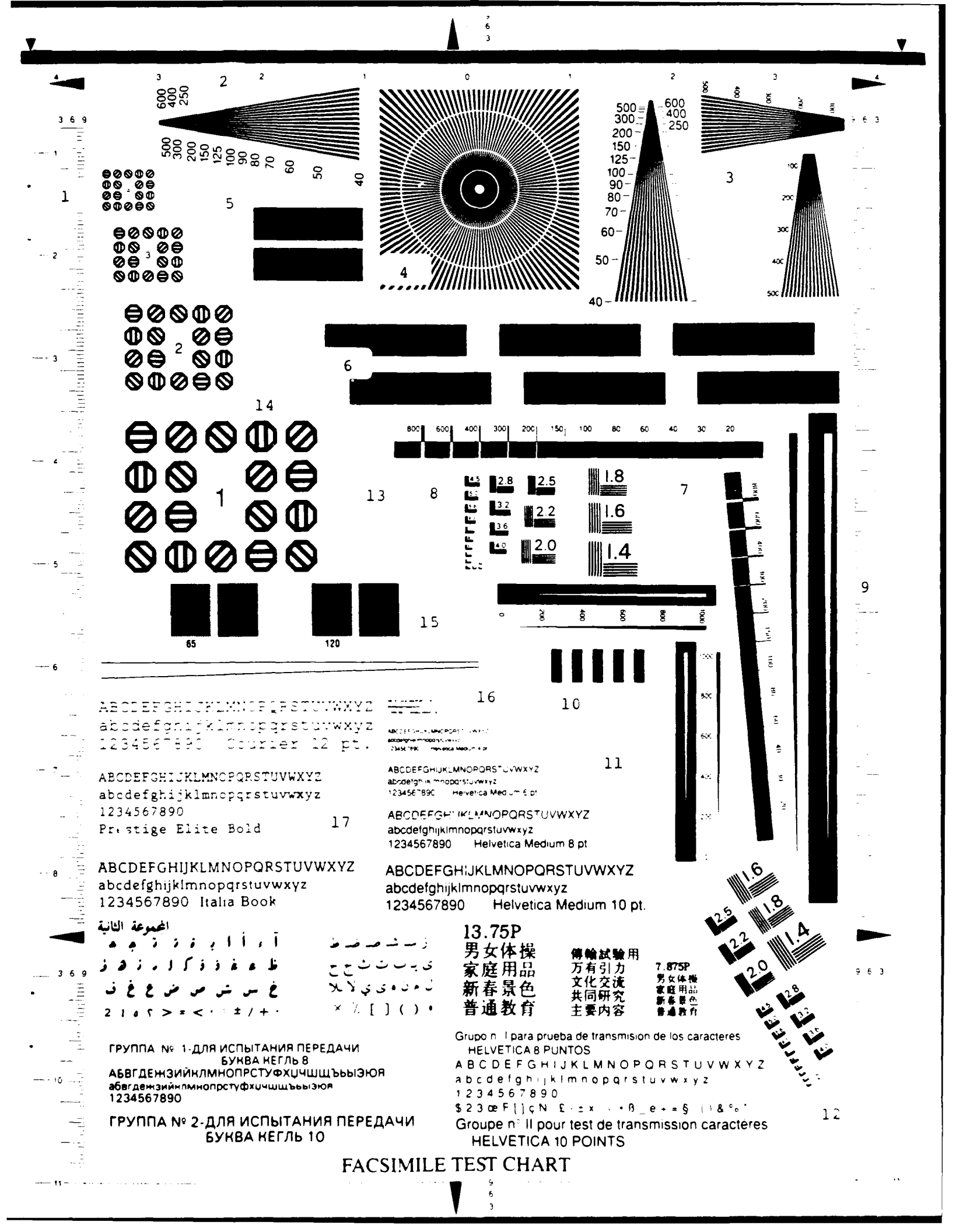
2. Scale in inches across the top, starting from 0 in the middle of the page with .1 inch scale markings. The border at the left side of the chart is marked in inches.

3. Four patterns of truncated fan-type multiple-line pattern with low taper rate. The larger ones are calibrated in black plus white lines per inch, and the smaller ones are calibrated in microns.

4. Gurley type Pestrecov Star pattern with circles of 50, 100 and 200 LPI.

5. Alternating black and white lines. Upper pattern is 150 lines per 25.4 mm, inclined at 3 degrees from vertical. The lower pattern is 200 lines per 25.4 mm, inclined at 2 degrees from vertical. The angle is to allow the lines to drift through a match and a mismatch with the photosensor array elements.

6. Black-white bar patterns of 100, 150, 200, 300, 400 and 600 lines per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男女体操
家庭用品
新春景色
普通教育
傳輸試驗用
万有引力
文化交流
共同研究
主要内容
7.875P
ГРУППА № 1-ДЛЯ ИСПЫТАНИЯ ПЕРЕДАЧИ
БУКВА КЕГЛЬ 8
АБВГДЕЖЗИЙКЛМНОПРСТУФХЦЧШЩЪЬЫЭЮЯ
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ГРУППА № 2-ДЛЯ ИСПЫТАНИЯ ПЕРЕДАЧИ
БУКВА КЕГЛЬ 10
Grupo n° I para prueba de transmision de los caracteres
HELVETICA 8 PUNTOS
A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
a b c d e f g h i j k l m n o p q r s t u v w x y z
1 2 3 4 5 6 7 8 9 0
Groupe n° II pour test de transmission caracteres
HELVETICA 10 POINTS
FACSIMILE TEST CHART

25.4 mm.

7. Isolated black and white lines. The vertical pattern is inclined at 5 degrees from vertical.

8. NBS type resolution pattern calibrated in line pairs (black plus white) per millimeter with the smallest patterns near the center of the chart.

9. Tapered isolated black and white line patterns with the line width calibrated in microns or inches.

10. Black-white bar pattern of 5 black plus white bars per 25.4 mm.

11. Parallel lines inclined at 5 degrees from vertical.

12. NBS type resolution pattern calibrated in line pairs (black plus white) per millimeter with the smallest patterns near the edge of the chart.

13. Diagonal line for checking irregularities in vertical pitch. Received lines with errors will show breaks or steps in this line.

14. ISO character hexagonal line patterns for readability testing.

15. Halftone dot screens of 10, 50 and 90 percent black. The 65 and 120 are the number of dots per 25.4 mm measured at a 45 degree angle.

16. Line crossing pattern. The center to center line separation is 0.15 inches on the left end and 0.05 inches on the right end. The number of scanning line crossings of both lines multiplied by 10 is the vertical line pitch in lines per 25.4 mm.

17. Text in English, Arabic, Chinese, Russian, Spanish and French. English text is in 12, 10, 8, 6, 4 and 2 point sizes.

3.2 Continuous Tone Monochrome Chart

This chart is titled "CONTINUOUS TONE FACSIMILE TEST CHART" (CT01). The overall size is 8 1/2 x 11 inches. The patterns that make up the chart are defined below. Again, refer to the corresponding encircled numbers in Figure 3. This chart is also part of Draft Recommendation T.xx.

1. A continuous (stepless) density wedge from black on the left to white on the right.

2. A reverse of the continuous wedge above (white on the left).

3. A 48-step tablet with 4 rows of 16 density steps from white to black. Steps are designed for equal perceptibility to a human observer.

4. A set of 16 horizontal gray scale strips, from black to white.

5. An architectural photo showing fine detail.

6. Portrait.

3.3 Four-color Printed Chart

This chart is titled "4-COLOR PRINTING FACSIMILE TEST CHART" (4CP01). The first version of this full-color chart was printed from 4-color separation negatives using the 3-M Matchprints process. This process is widely used in the color printing industry to check the quality of the color separations before setting up the color printing presses. The Matchprints should have a greater precision than would be possible on high quality printing presses.

Some of the patterns are the same as the Black/white Test Chart, or modifications thereof to print with color primaries rather than black. Multiple-line and single-line resolution test patterns have been retained, but not in the large variety of pattern types found in the Black-white Test Chart. The fine line patterns on this chart are printed at full contrast, with the color line width the same as the

1

2

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

3

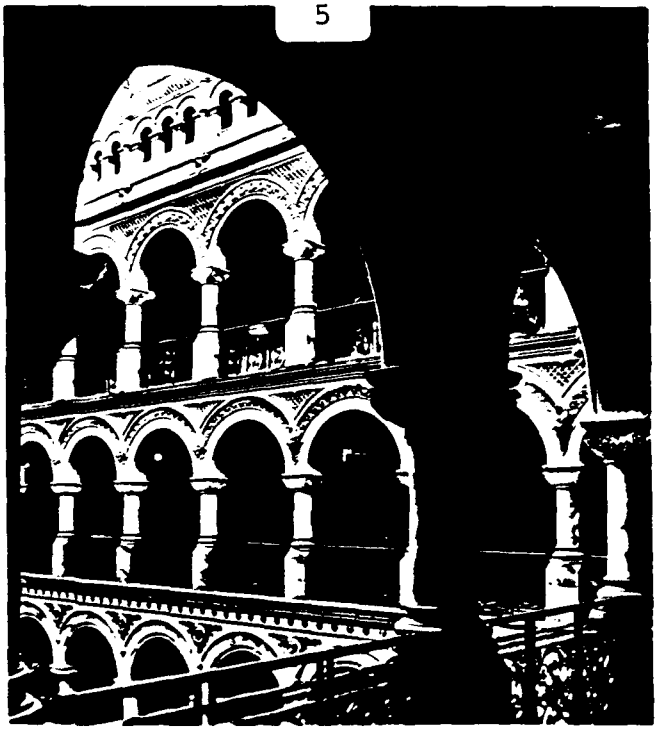
A

B

C

4

5



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EIA Facsimile Test Chart Continuous Tone Addendum

white spaces between lines. The pattern numbers correspond to those in Figure 4.

1. CCITT border of 4 scales with millimeter markings. The 5 and 10 mm lines are extended. The red arrows near the ends are 8 1/2 inches apart and centered on the page. The top border is red (solid magenta and yellow printing). The right border is green (solid yellow and cyan printing). The left border, also marked in inches, is blue (solid cyan and magenta printing). Bottom border, three segments - cyan, magenta, and yellow.

2. Black bar at the top across full page width and a red scale in inches under it, starting from 0 in the middle of the page with .1 scale markings.

3. Three patterns of Gurley type Pestrecov Star of solid, non-screened, tapered-width lines with circles of 50, 100, & 200 LPI.

3.1 The left pattern is divided into 4 segments. Clockwise from the left are C, M, Y, K.

3.2 The center pattern is divided into two parts. The left side has a repeating pattern of adjacent CMY tapered lines. The right side has a repeating pattern of adjacent RGB tapered lines.

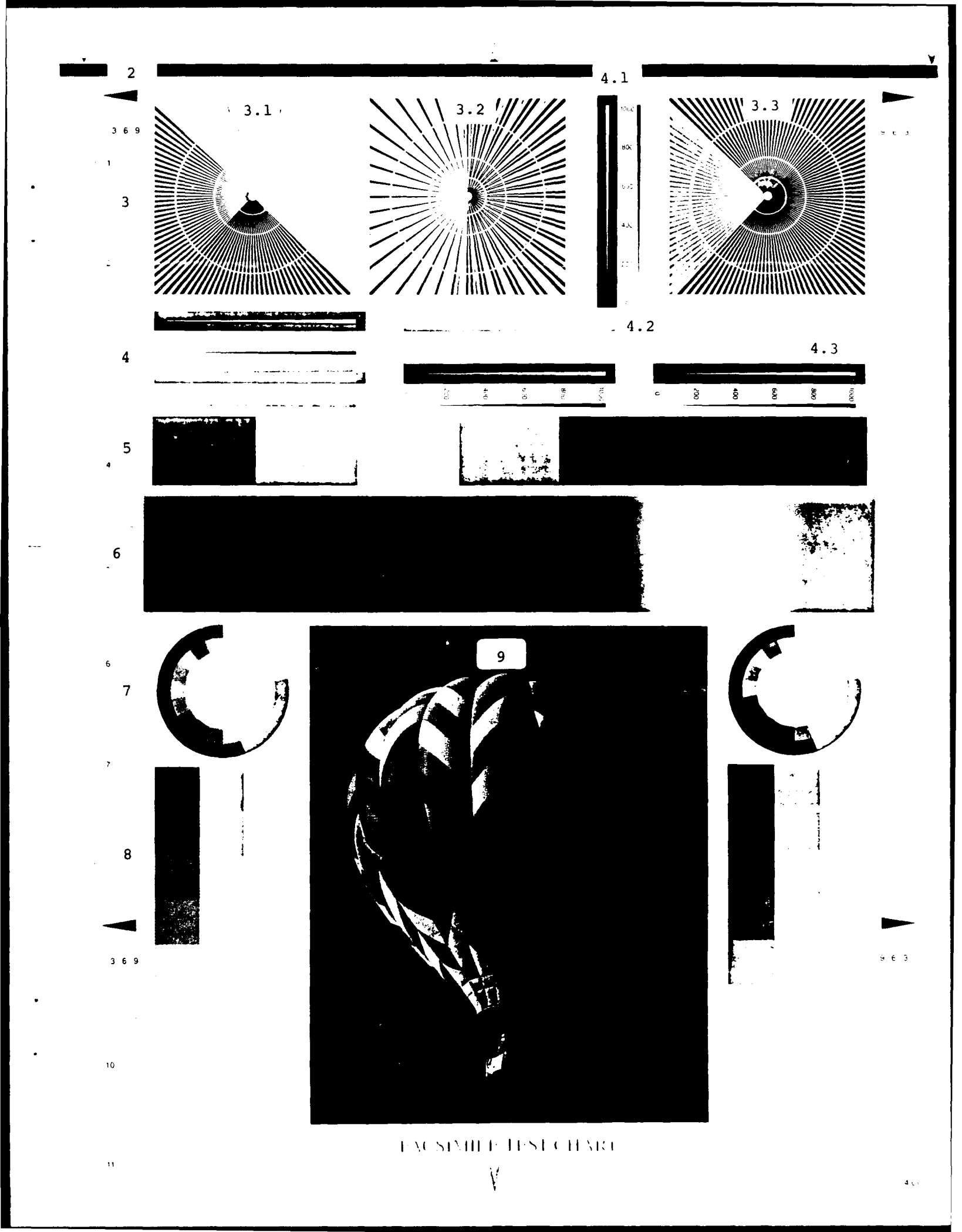
3.3 The right pattern is divided into 4 segments. Clockwise from the left are R,G,B,K.

4. Pairs of positive and negative tapered, isolated line patterns with the line width calibrated in microns.

4.1 This vertical pattern is printed in black.

4.2 The upper row of patterns is printed in C, M, & Y, starting at the left.

4.3 The lower row of patterns is printed in R, G, & B, starting at the left.


2
3.1
3.2
4.1
3.3
3
4.2
4
4.3
5
6
9
7
8
10
11

5. Solid unscreened blocks of printing ink colors. Starting at the left - Cyan, Magenta, Yellow, Red (magenta + yellow), green (yellow + cyan), blue (cyan + magenta).

6. Rainbow color bar has red at the left and violet at the right. It is divided into two horizontal sections. The upper section is an 85 line screen, and the lower portion is a 150 line screen.

7. Color circles have 18 segments around the periphery for saturated colors. Each of the inner concentric circles towards the center has less saturation.

8. Printing color primaries in 8 steps of saturation, with 100% (solid color) at the top and 12% dot size at the bottom. The left pattern is 85 line screen and the right is 150 line screen.

9. Color photograph is 85 line screen on the left and 150 line screen on the right.

At the September 1990 meeting of Study Group VIII a first draft of this color test chart was presented and discussed (Delayed Document 158). Based on the comments that we have received from international color experts, the chart will be revised and re-printed.

3.4. Continuous tone color chart

This chart is titled "PHOTOGRAPHIC COLOR FACSIMILE TEST CHART" (PC01). The content will be similar to the screened chart (4CP01), but will be printed on positive photographic paper. If direct prints can be made without a negative, the chart can be calibrated to the desired tri-stimulus values. If prints are made from a negative however, the color achieved will depend upon the printing process and will be subject to some variations. As an example, the color primaries for the color test charts prepared by the Society of Electrophotography of Japan are quite different from those that are common in the United States. The color renditions produced by both of them are very good, however. As yet, no test print has been made for this chart, and final printing alternatives are being explored.

4.0 SCANNED IMAGES

Seven Scanned Images color images and two gray scale images form the base for the facsimile color test image suite. Gray scale imagery was included at the request of many test chart users to provide comprehensive testing capabilities. For instance, some color systems have difficultly in accurately reproducing gray scales. An example of this type of system might be a CMY printer, which does not produce black as a separate ink. To avoid color artifacts when reproducing gray scales, the printer must accurately register each color with the proper intensity.

4.1 Color Images

The seven baseline color images are toys, computer-generated spheres, a hot air balloon, a graphics image, and three patterns of a Gurley-type Pestrecov Star. These images contain several desirable characteristics for testing color systems. Some of these characteristics follow.

1. An image may contain gradual transitions in color over broad image areas. (This is useful for showing possible contouring effects of certain compression algorithms or color printing limitations.)
2. An image may contain a range of textures and other small, repetitive patterns.
3. An image may contain sharp boundary transitions between various color combinations.
4. An image may contain areas of high detail and contrast to challenge compressibility.
5. An image may contain widespread variations in luminance, hue, and saturation.
6. An image may contain subject material representative of typical applications.

4.1.1 Toys

The 3.6 x 4.2 inch toys image contains a variety characteristics desirable for a color test image. (See Figure 5.) It provides a range of textures and patterns. Compare the fuzziness of the stuffed animals to repetitiveness of the blinds to the color combinations present in the man's shirt. The presence of both bright and pastel colors provide widespread variations in luminance, hue, and saturation. In addition, the image is rich in slowly varying color textures mixed with sharp color boundaries. For example, the slowly varying pink of the panther's leg next to the plaid of the girl's skirt.

Figure 5. Gray Scale Rendition of Kids with Stuffed Animals

4.1.2 Computer-generated Spheres

The 3.6 x 1.65 inch computer generated spheres image shows various-sized differently-colored spheres on a black background. (See Figure 6.) In general, each sphere is one color, shaded to give a three dimensional appearance. The gradual transition in color of each sphere's shading provides an excellent medium for discerning possible contouring effects. If contouring is present, it will usually manifest

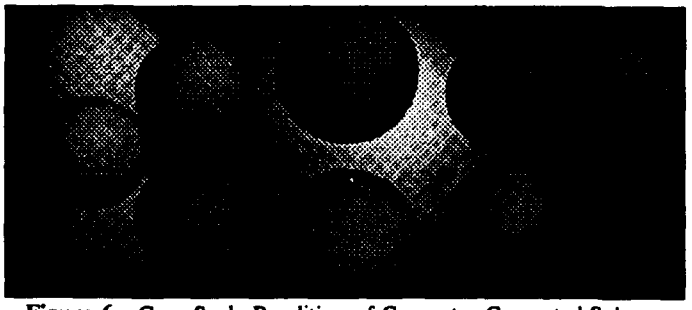


Figure 6. Gray Scale Rendition of Computer Generated Spheres

itself as a series of concentric circles with slightly different colors. The spheres' edges also provide sharp boundaries against both the black background and other spheres.

4.1.3 Hot Air Balloon

The 4 x 5 inch hot air balloon image shows a multicolored balloon in contrast to a deep blue sky. (See Figure 7.) The sky provides a very broad area for showing possible contouring effects of some compression algorithms and some printing processes. It consists of almost imperceptible, smooth gradual variations from one contour to another. These contours are mainly due to thin, almost invisible bands of clouds. In contrast, the balloon provides sharp vertical, horizontal, and vertical boundary transitions between various color combinations. Its panels contain rainbow colors organized in both diagonal and vertical directions.

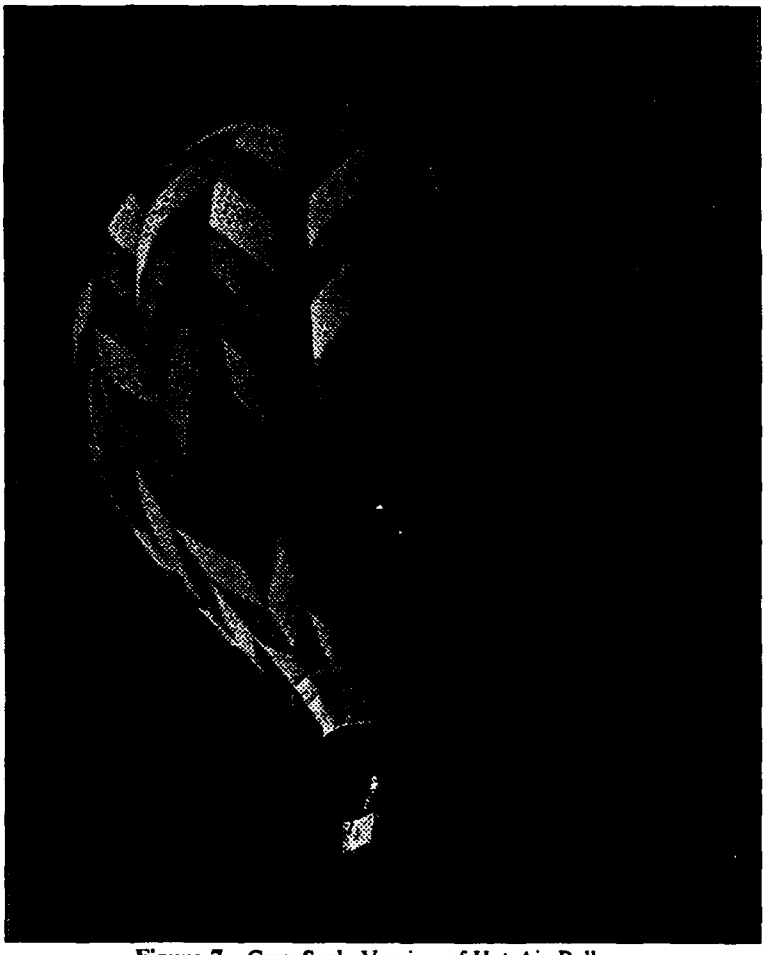


Figure 7. Gray Scale Version of Hot Air Balloon

4.1.4 Graphics Image

The 3.6 x 2.55 inch graphics image is an example of magazine artwork. (See Figure 8.) It uses pastel colors to denote surfaces and fine black lines to enhance details. It contains a number of repetitive patterns coupled with sharp boundaries between various colors.

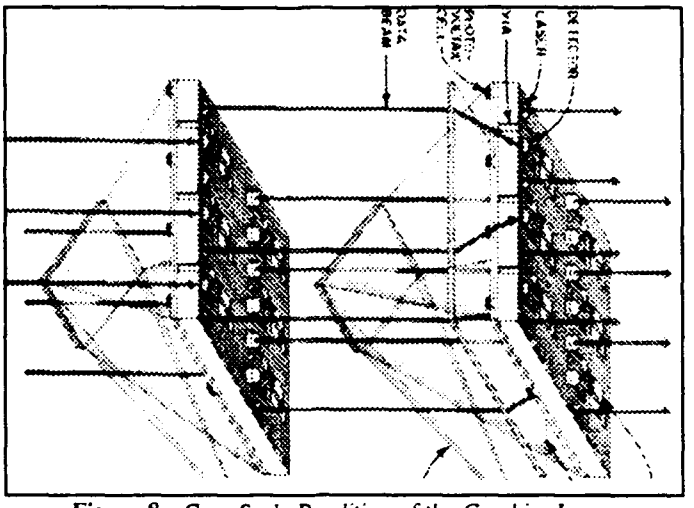


Figure 8. Gray Scale Rendition of the Graphics Image

4.1.5 Gurley-type Pestrecov Star Patterns

The three 1.975 x 1.975 inch Gurley-type Pestrecov star patterns consist of tapered-width lines with superimposed circles. (Figure 9 is an example of one.) Widths of the circles are 50 lines/inch for the outermost and 100 lines/inch for the two innermost. These stars provide a number of sharp vertical, horizontal, and diagonal boundaries between known color combinations. One star pattern is divided into four segments. Clockwise from the left, these segments are the colors cya. , magenta, yellow, and black. These colors are usually the primary colors of most printing processes. Thus this star provides an excellent means to verify a printing system's regularity of color and resolving capabilities. Another is divided into two parts. Its left side has a repeating pattern of adjacent CMY tapered lines. Its right side has a repeating pattern of adjacent RGB tapered lines. The RGB tapered lines test the ability of most color printing systems to reproduce the color complements of its printing process at finer and finer resolutions. The last pattern is divided into four segments. Clockwise from the left, these segments are

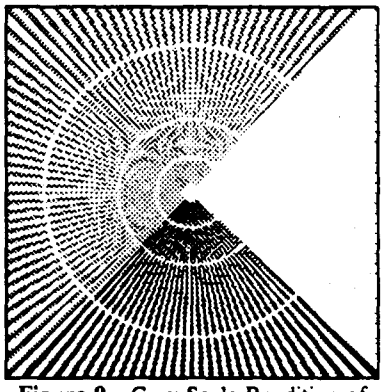


Figure 9. Gray Scale Rendition of Gurley-type Pestrecov Stars

the colors red, green, blue, and black.

4.2 Gray Scale Images

The two gray scale images are an architectural photo and a portrait. These images are taken from test chart CT01.

4.2.1 Architectural Photo

The 3.4 x 3.725 inch architectural photo combines the smooth textures of the interior surfaces of the arches with the fine detail of the handrails, capitals (tops of the columns), and the exterior surfaces of the arches. (See Figure 10.) The interior surfaces near the ceiling are areas demonstrating gradual transitions in gray scale tones. They are excellent testbeds for showing the contours and artifacts some compression algorithms and printing systems might produce for gradually transitioning gray tones. Note the many fine horizontal, vertical, diagonal and curved lines. These are good for testing a printing system's registration capabilities at fine resolutions.

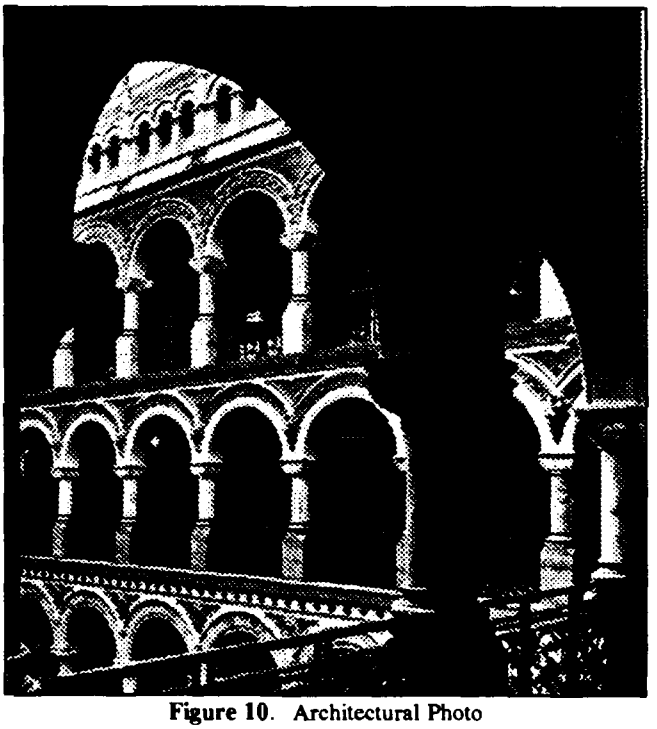


Figure 10. Architectural Photo

4.2.2 Portrait

The 3.4 x 3.725 inch portrait of the man contains many slowly varying contours and textures. (See Figure 11.) It also has a number of adjacent low and high contrast areas. Note the barely visible boundaries in the collar of the sweater, as compared to the high contrast detail present in the face.

4.3 Image format

In order to provide color-calibrated data, the continuous tone images will be stored on magnetic tape as tri-stimulus values. A specific RGB version will also be provided for a known set of phosphors. In addition, a halftone version of some of the images, calibrated to a known printer, will be supplied. The details of these image formats are described in a Users Guide.

Figure 11. Portrait

5. CONCLUSIONS AND RECOMMENDATIONS

A suite of four test charts have been specified to meet the requirements defined for color facsimile testing. Three of the four have been produced and discussed by experts from U. S. and international standards organizations. As a result of these discussions, a number of changes have been recommended to these three charts. The following sections describe the proposed changes to the charts. The elements of the fourth chart (continuous tone color), have been outlined; detailed design and prototyping are the next steps to be accomplished.

5.1 Monochrome Charts

Based on the comments that we have received and further review, a number of minor changes to the charts are planned. These changes are as follows:

1. On Test Chart BW01 the upper line of Pattern No. 16 has been changed to slant downward to the right instead of being horizontal. This will prevent either line from being scanned horizontally, even if the chart feeds through slightly skewed. This change will simplify the evaluation of line crossings.

2. On Test Chart CT01 the width of the gray scale strips (Pattern No. 4) will be extended to the edge of the chart, providing a better test for potential light fall-off near the page edges.

3. On Test Chart CT01 the 48-step tablet (Pattern No. 3) is being modified to improve the uniformity of the density steps at the light end. These density values range from approximately 0.07 to 2.04 for this pattern.

New versions of these two charts will be prepared, together with the revised T.xx, and submitted in final form to Study Group VIII at its March 1992 meeting.

As soon as the final versions of Chart BW01 and Chart CT01 have been completed they will be scanned and made available in digital form. It is planned to provide pel densities of both 200 and 400 pels per inch. Chart BW01 will be available both on 9-track magnetic tape and pc-compatible diskettes. Chart CT01

also will be available on magnetic tape, and where practical on diskette. It is planned to provide a table of the coordinates (pel positions) of the major features of the charts.

5.2 Color Chart

The following changes are planned for chart 4CP01. The revisions will be incorporated in a new version and presented at the next meeting of Study Group VIII.

1. Gauging color resolution by small primary color dot rosettes in low saturation color patches may be more meaningful than the tapered single line and multiple line targets of the last color test chart submitted. The results with the current test targets are quite sensitive to differences in match between the scanning line and the target, but the CMYK resolution target at the top left will be retained.

2. The rainbow may be replaced by selected color patches. To allow room for a large number of flesh tones, color patches as small as one centimeter square are being considered. Large area color patches will be used for primary color blocks (CMY and RGB).

3. It is planned to add type fonts in color and at various screen dot percentages. The colors and dot sizes will be selected to match some of the color test patches.

4. To simulate magazine pages, some text in solid black will be added. This will test the very difficult coding task of performing efficiently for both color and B/W.

5. Two photos are planned to replace the current photograph of a balloon: One is a photograph of children and toys in a toy shop, to be very useful for testing color performance; The other photograph, computer generated, shows a number of overlapping balls, each of a different color, on a black background. The computer program generates any color with the number

and the size of balls as specified. They are good for testing bit precision and smoothness, and the gradual shading of the color makes them look three-dimensional.

APPENDIX A

Recommendation T.XX

STANDARDIZED TEST CHARTS FOR DOCUMENT FACSIMILE TRANSMISSIONS

The CCITT,

considering

(a) that a standardized test chart to check the quality of document facsimile transmissions will have great advantages. Owing to the development of international document facsimile transmission services, a great variety of characters and symbols, including ideographic symbols, are involved and must be taken into consideration.

(b) that advancing technology has led to the definition of two new test charts:

- one, high contrast "Facsimile Test Chart" for evaluating the technical quality of the page and the legibility of the text;

- the other, "Continuous Tone Addendum" for the evaluation of the technical quality of continuous tone information;

unanimously adopts the view

(1) that tests of document facsimile transmission quality should be carried out in the international service using the CCITT standardized test charts;

(2) that these test charts should be produced by the ITU under the supervision of the CCITT and should be offered for sale by the ITU. There are two types of charts:

- Test chart No. 4: "Facsimile Test Chart" intended for the general evaluation of technical quality,

- Test chart No. 5: "Continuous Tone Addendum" intended to check tonal quality.

The charts are described in Annex A; the specimens printed in Annex A cannot be used for measurements;

(3) that the charts should be used with facsimile apparatus in accordance with appropriate CCITT T series recommendations.

ANNEX A

(to Recommendation T.xx)

Description of the standardized document facsimile test charts

1 Dimensions of the test charts

	Test Chart No. 4	Test Chart No. 5
- length:	298 mm	279 mm
- width:	222 mm	216 mm

They are divided into sections marked:

- 2.1 - 2.17 on Test chart No. 4 for resolution testing,

- 3.1 - 3.6 on Test chart No. 5 for tonal quality testing.

These section markings are also used to designate the following paragraphs which describe the given section.

2 Test Chart No. 4 - High Resolution Facsimile Monochrome Test Chart - High Contrast Black-white

Pattern Descriptions

The overall size of the printed chart is 222 x 298 mm. The patterns that make up the chart are defined below. Refer to the corresponding encircled numbers on the attached sample chart.

2.1 *Pattern 1 - CCITT border of 4 scales with millimeter markings.*

The 5 and 10 mm lines are extended. The arrows near the ends are 8 1/2 inches apart and centered on the page.

2.2 *Pattern 2 - Scale in inches across the top*

Starting from 0 in the middle of the page with 0.1 inch scale markings. The border at the left side of the chart is marked in inches.

2.3 *Pattern 3 - Four patterns of truncated fan-type multiple-line pattern with low taper rate.*

The larger ones are calibrated in black plus white lines per inch, and the smaller ones are calibrated in microns.

2.4 *Pattern 4 - Gurley type Pestrecov Star pattern with circles of 50, 100* and 200 LPI.

2.5 *Pattern 5 - Alternating black and white lines.*

Upper pattern is 150 lines per 25.4 mm, inclined at 3 degrees from vertical. The lower pattern is 200 lines per 25.4 mm, inclined at 2 degrees from vertical. The angle is to allow the lines to drift through a match and a mismatch with the photosensor array elements.

2.6 *Pattern 6 - Black-white bar patterns*

Bar Patterns of 100, 150, 200, 300, 400 and 600 lines per 25.4 mm.

2.7 *Pattern 7 - Isolated black and white lines.*

The vertical pattern is inclined at 5 degrees from vertical.

2.8 *Pattern 8 - NBS type resolution pattern*

Calibrated in line pairs (black plus white) per millimeter with the smallest patterns near the center of the chart.

2.9 *Pattern 9 - Tapered isolated black and white line patterns with the line width calibrated in microns or inches.*

2.10 *Pattern 10 - Black-white bar pattern of 5 black plus white bars per 25.4 mm.*

2.11 *Pattern 11 - Parallel lines inclined at 5 degrees from vertical.*

2.12 *Pattern 12 - NBS type resolution pattern*

Calibrated in line pairs (black plus white) per millimeter with the smallest patterns near the edge of the chart.

2.13 *Pattern 13 - Diagonal line for checking irregularities in vertical pitch.*

Received lines with errors will show breaks or steps in this line.

2.14 *Pattern 14 - ISO character hexagonal line patterns for readability testing.*

2.15 *Pattern 15 - Halftone dot screens of 10, 50 and 90 percent black.*

The 65 and 120 are the number of dots per 25.4 mm measured at a 45 degree angle.

2.16 *Pattern 16 - Line crossing pattern.*

The center to center line separation is 0.15 inches on the left end and 0.05 inches on the right end. The number of scanning line crossing of both lines multiplied by 10 is the vertical line pitch in lines per 25.4 mm.

2.17 *Pattern 17 - Text in English, Arabic, Chinese, Russian, Spanish and French. English text is in 12, 10, 8, 6, 4 and 2 point sizes.*

3 Test Chart No. 5 - High Resolution Facsimile Monochrome Test Chart - Continuous Tone Gray Scale

Pattern Descriptions

The overall size of the printed chart is 279 x 216 mm. The patterns that make up the chart are defined below. Refer to the corresponding numbers in Figure 1.

3.1 *Pattern 1 - A continuous (stepless) density wedge*

From black on the left to white on the right.

3.2 *Pattern 2 - A reverse of the continuous wedge above*

White on the left.

3.3 *Pattern 3 - A 48-step tablet*

With 3 rows of 16 density steps from white to black. Steps are designed for equal perceptibility to a human observer.

Table 1
Pattern 3 Density Values

	A	B	C
1	0.0156	0.5148	1.0140
2	0.0468	0.5460	1.0452
3	0.0780	0.5772	1.0764
4	0.1092	0.6084	1.1076
5	0.1404	0.6396	1.1388
6	0.1716	0.6708	1.1700
7	0.2028	0.7020	1.2012
8	0.2340	0.7332	1.2324
9	0.2652	0.7644	1.2636
10	0.2964	0.7956	1.2948
11	0.3276	0.8268	1.3260
12	0.3588	0.8580	1.3572
13	0.3900	0.8892	1.3884
14	0.4212	0.9204	1.4196
15	0.4524	0.9516	1.4508
16	0.4836	0.9828	1.4820

Table 2
Pattern 4 Density Values

Strip	Density
1	1.937
2	1.812
3	1.687
4	1.562
5	1.437
6	1.312
7	1.187
8	1.062
9	0.937
10	0.812
11	0.687
12	0.562
13	0.437
14	0.312
15	0.187
16	0.062

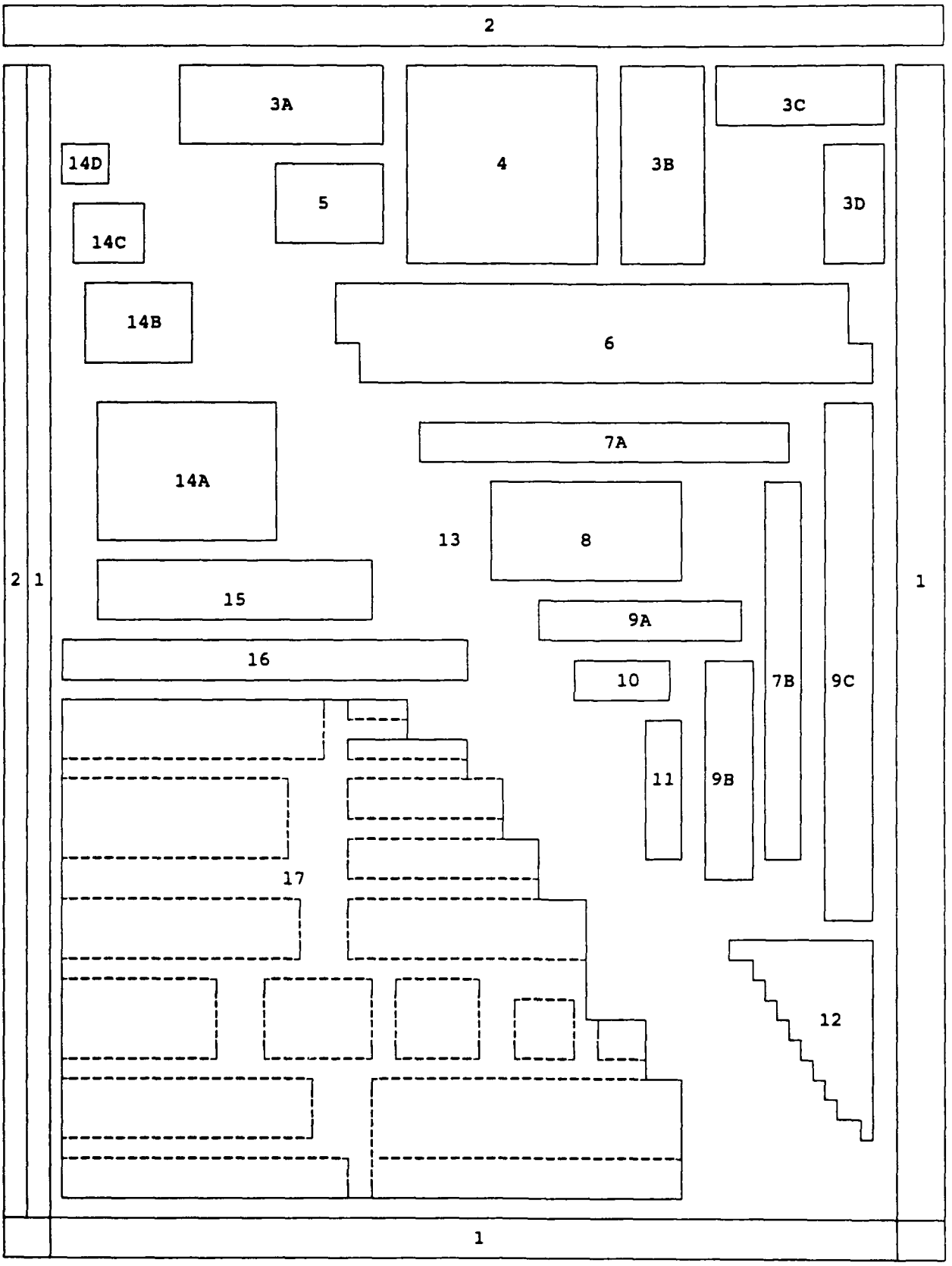
3.4 *Pattern 4 - A set of 16 horizontal gray scale strips*

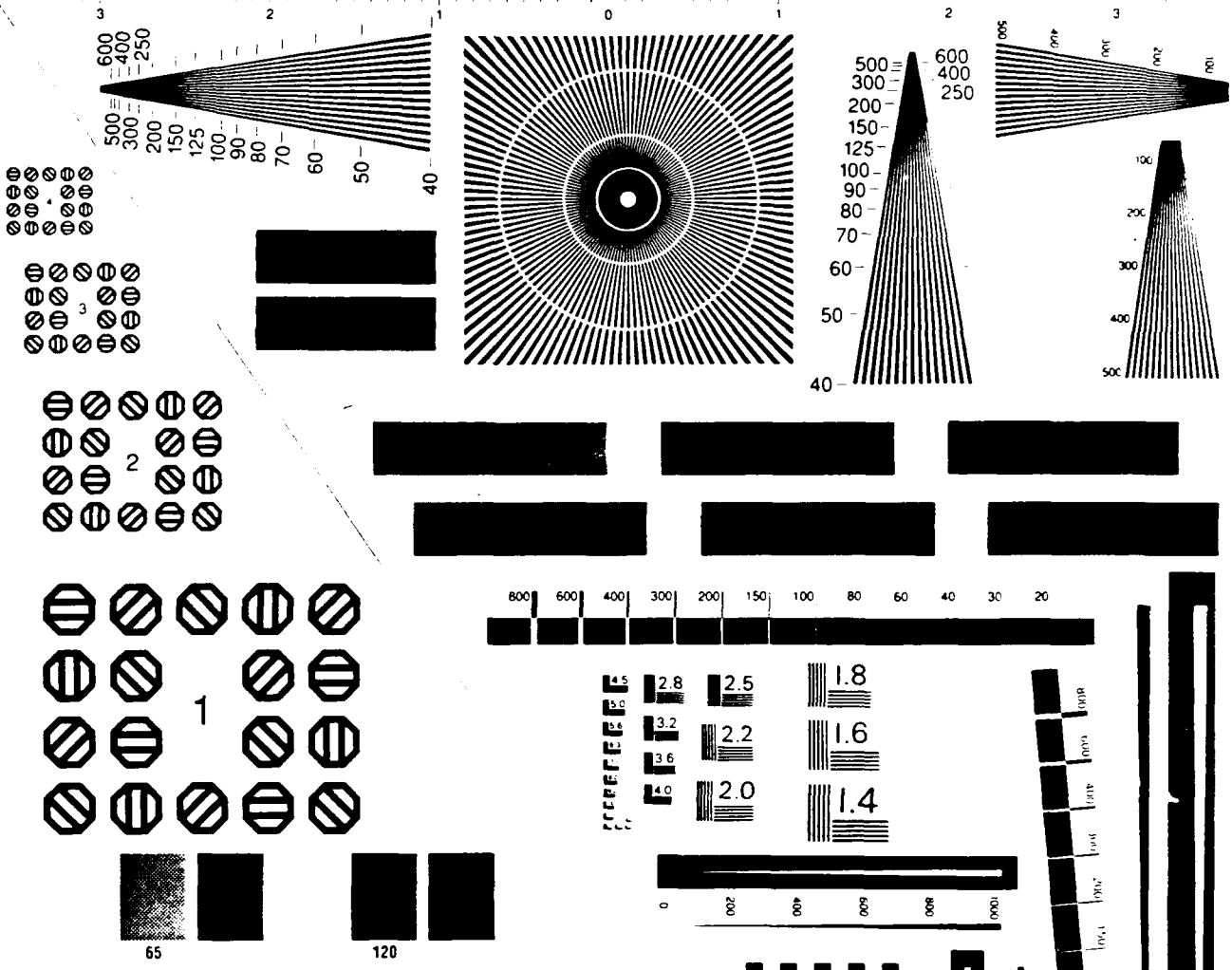
From black to white.

3.5 *Pattern 5 - An architectural photo showing fine detail.*

3.6 *Pattern 6 - Portrait.*

TEST CHART 4 - PATTERN ARRANGEMENT





ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz
1234567890 Courier 12 pt.

ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz
1234567890
Prestige Elite Bold

ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz
1234567890 Italia Book

ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz
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abcdefghijklmnopqrstuvwxyz
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ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz
1234567890 Helvetica Medium 10 pt.

المجموعة الثانية

13.75P
男女体操
家庭用品
新春景色
普通教育

傳輸試驗用
万有引力
文化交流
共同研究
主要内容

7.875P
男女体操
家庭用品
新春景色
普通教育

ГРУППА № 1-ДЛЯ ИСПЫТАНИЯ ПЕРЕДАЧИ
БУКВА КЕГЛЬ 8
АБВГДЕЖЗИЙКЛМНОПРСТУФХЦЧШЩЪЬЫЭЮЯ
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ГРУППА № 2-ДЛЯ ИСПЫТАНИЯ ПЕРЕДАЧИ
БУКВА КЕГЛЬ 10

Grupo nº I para prueba de transmision de los caracteres
HELVETICA 8 PUNTOS
A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
a b c d e f g h i j k l m n o p q r s t u v w x y z
1 2 3 4 5 6 7 8 9 0
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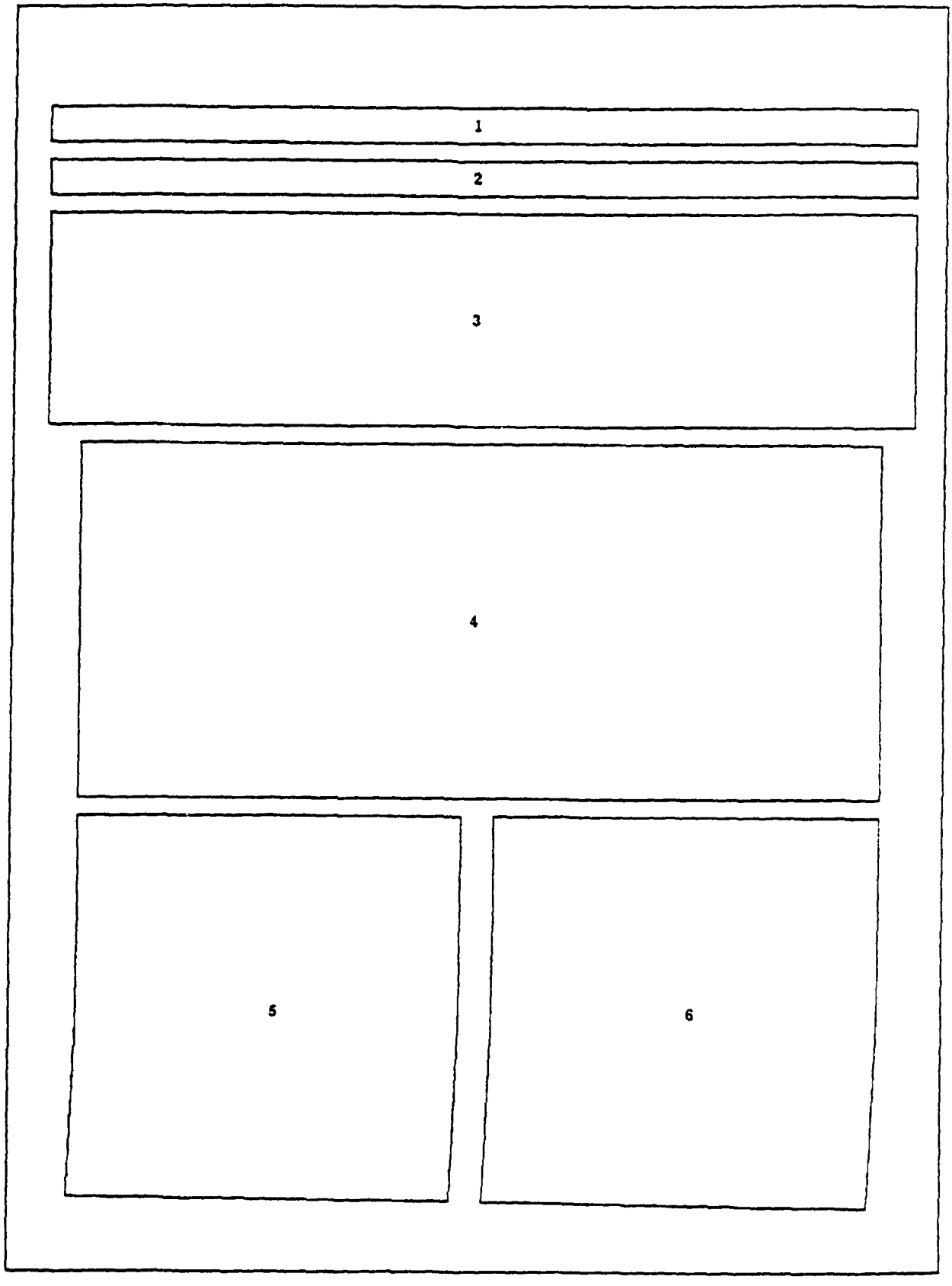
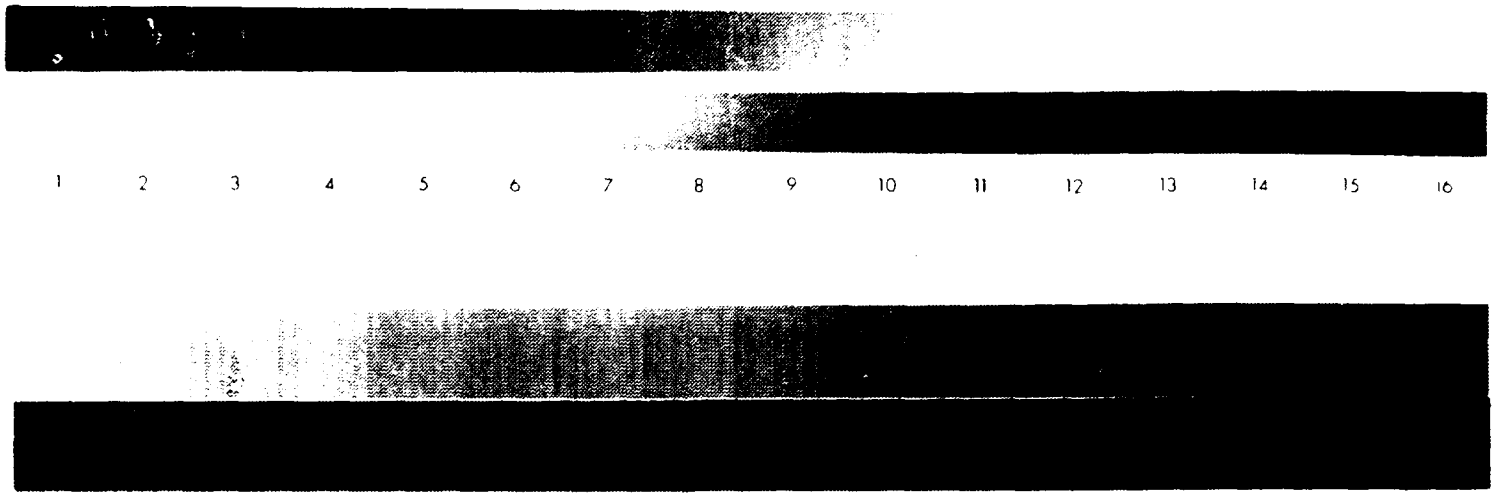
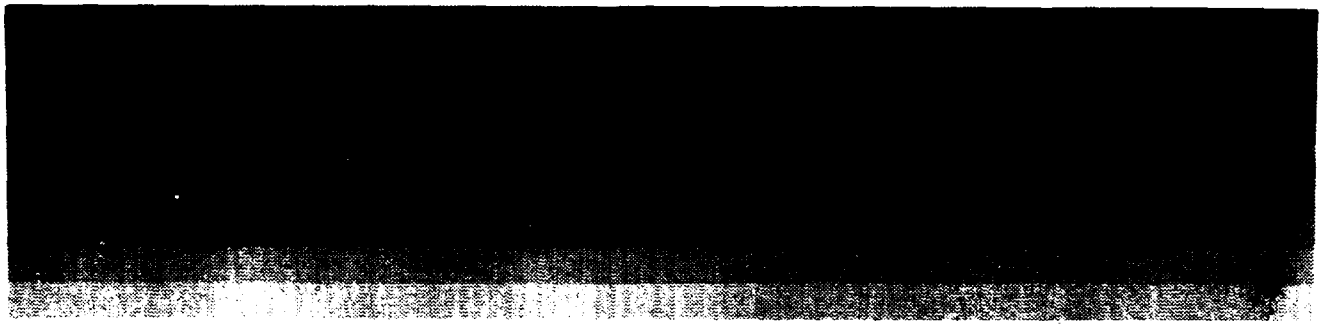
Groupe nº II pour test de transmission caracteres
HELVETICA 10 POINTS

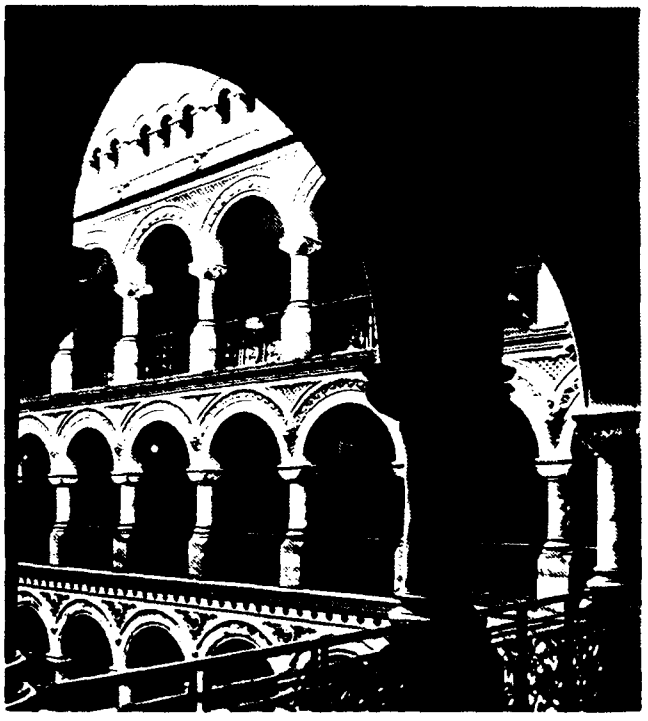
FACSIMILE TEST CHART

TEST CHART 5 - PATTERN ARRANGEMENT









EIA Facsimile Test Chart Continuous Tone Addendum